National IT R&D Program

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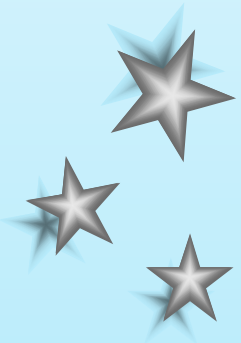
Overview

- Background
- History
- Organization
- PITAC recommendations
- Current activities
- Conclusions



Information Technology is one of the key factors driving progress in the 21st century

Information Technology is transforming the way we:

- Communicate
- Deal with information
- Learn
- Practice health care
- Conduct commerce
- Work
- Design and build things
- Conduct research
- Deal with the environment
- Conduct government

Information technology is creating a new foundation for business, scientific research, and social interaction

Aggressive IT R&D is essential for achieving 21st century aspirations

- Stronger national security
- Improved quality and delivery of health care
- Safer and cheaper transportation by air, land, and sea
- Improved climate models to support more informed decisions
- More efficient and responsive government
- Better quality and delivery of education and training to all Americans
- Decreased reliance on untested and insecure information systems
- Increased productivity of research in all disciplines
- A safer and improved environment through efficient design and operation of buildings, vehicles, and equipment
- Better warnings of dangerous weather
- Faster response to hazardous materials releases

Opportunities for innovation in IT are large – and becoming even more important

Information Technology – An Essential National Interest

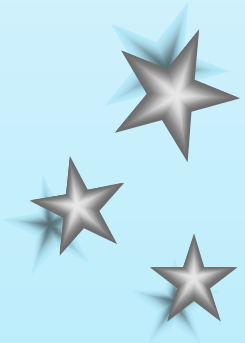
Past Federal investments have yielded spectacular returns

- The Internet, the first graphical Web browser, advanced microprocessors
- IT accounts for one-third of U.S. economic growth and employs 10.4 million Americans
- Business-to-consumer e-commerce is projected to grow to $156 billion by 2005
- From 1994 to 2001, the number of U.S. home Web users has increased from 3 million to more than 89 million
- More than a third of a billion people worldwide now use the Internet

We have an essential national interest in ensuring a continued flow of good new ideas and trained professionals in information technology

The Federal government plays a critical role in supporting fundamental IT R&D

- Federally-sponsored research has helped build the technology base on which the IT industry has grown
- Fundamental research is key to stimulating innovation, and innovation is key to continued U.S. leadership in IT
- The Federal government funds basic research not traditionally funded by the commercial sector
  - High risk, innovative ideas whose practical benefits may take years to demonstrate
- Federal funding for research plays a critical role in educating students in computing, communications, IT, and IT applications



Industry's Role in IT R&D

- The industrial R&D investment, though large in dollars, is different in nature:
  - Research is focused on short-term results – more than 90% of IT R&D expenditures are for product development, and product life cycles are typically 18 months or less
- Federal funding is often carried out in close cooperation with industry (for example, joint testbeds)
- The benefits of fundamental research are generally too far in the future and too uncertain to receive significant industry support. However, …
- Federal IT research drives industry innovation by generating many technologies later commercialized into pervasive products (such as the mouse, high-speed networks, Web browsers, and search engines)
- "The fundamental investments in university research by the Federal government have served to train the majority of our information technology professionals." — IT industry leaders on the President's Information Technology Advisory Committee

History of The Federal HPCC Initiative (HPC Act of 1991, P.L. 102-194)

- Chartered by Congress FY 1992 through FY 1996 with the High Performance Computing Act of 1991
- Focused on:
  - High Performance Computing Systems
  - Advanced Software Technology and Algorithms
  - National Research and Educational Network
  - Information Infrastructure Technology and Applications
  - Basic Research and Human Resources
- Was coordinated through the High Performance Computing, Communications, and Information Technology (HPCCIT) Subcommittee and NCO

HPCC Program Goals

- Extend U.S. technological leadership in high performance computing and computer communications
- Provide wide dissemination and applications of these technologies to speed the pace of innovation and improve national economic competitiveness, national security, education, health care, and the global environment
- Provide key enabling technologies for the National Information Infrastructure (NII) and demonstrate select NII applications

Federal HPCC Program Contributions

- Scalable parallel systems
- Enabling technologies for workstations, distributed systems
- Microkernel operating systems
- Internet networking technology
- Information infrastructure, including early WWW browsers
- Research for digital libraries
- Gigabit testbeds
- Supercomputer Centers
- Grand Challenge Applications
- National Challenge Applications
- Mission applications: e.g., national security, medicine, environment, and education

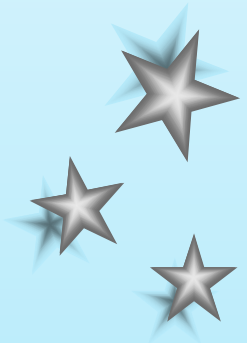
From HPCC to IT R&D

Next Generation Internet (NGI) Initiative

- Presidential initiative
  - Announced in October 1996
    - University based Internet2 announced shortly before
  - Begun in FY 1998
  - Ended in FY 2001, having met its goals
- Approximately $100 million per year
- Funded by six agencies
  - DARPA, NSF, NASA, DOE, NIH/NLM, NIST
- Several other agencies collaborated
- Cooperated with
  - UCAID's Abilene and Internet2
  - AT&T, Cisco, Sprint, WorldCom, ...
- NGI was always part of the Large Scale Networking PCA

NGI Goals

- Conduct R&D in next generation networking technologies to add functionality and improve performance
- Develop NGI testbeds, emphasizing end-to-end performance, to support networking research and demonstrate new networking technologies
  - At least 100 sites at speeds 100 times (100x) faster than the then current Internet
  - At least 10 sites at speeds 1,000 times (1,000x) faster than the then current Internet
- Develop and demonstrate at least 100 revolutionary applications that meet important national goals and missions and that rely on the advances made in the first two NGI goals



NGI Research Accomplishments

- DARPA
  - Optical networking
  - 1,000x SuperNet testbed
  - SuperNet applications
- NSF
  - 100x testbed
  - Broad spectrum of applications
- DOE — Collaboratory technologies and tools
  - An example is combustion corridors
- NASA — NGIX-West
- NIST — Collaboration with manufacturers on standards
- NIH/NLM
  - Health care applications
  - Health care community awareness of NGI's potential usefulness

NGI Accomplishments

- Testbed
  - **Established two testbeds**
    - The 100x NGI testbed connects more than 150 sites (goal was 100)
    - The 1,000x SuperNet testbed connects 15 sites (goal was 10)
  - **NGI successfully transitioned high performance networking to the private sector**
    - Abilene
    - vBNS+
- Applications
  - **Developed more than 100 NGI applications**
    - Additional hundreds are being developed by universities and industry using NGI testbeds

Information Technology R&D Program

- Evolved from the Federal HPCC, CIC, and NGI programs
- Provides a mechanism for focused long-term interagency R&D in information technologies
- $2 billion multi-agency Information Technology R&D Program
  - 12 agencies and departments coordinated via a “virtual agency” coordination/management structure
  - Coordinated by the National Coordination Office for Information Technology Research and Development
- Assessed by the President’s Information Technology Advisory Committee

Participating Agencies and Departments

- National Science Foundation (NSF)
- Defense Advanced Research Projects Agency (DARPA)
- National Institutes of Health (NIH)
- National Aeronautics and Space Administration (NASA)
- Department of Energy Office of Science (DOE/OS)
- National Security Agency (NSA)
- National Institute of Standards and Technology (NIST)
- National Oceanic and Atmospheric Administration (NOAA)
- Agency for Health Research and Quality (AHRQ)
- Office of the Deputy Under Secretary of Defense for Science and Technology (ODUSD (S&T))
- Environmental Protection Agency (EPA)
- Department of Energy National Nuclear Security Administration (DOE/NNSA)

Coordination of IT R&D Programs

WHITE HOUSE

Executive Office of the President
Office of Science and Technology Policy

National Science and Technology Council

President's Information Technology Advisory Committee (PITAC)

U.S. Congress

IT R&D Authorization and Appropriations Legislation

National Coordination Office (NCO) for Information Technology Research and Development

Interagency Working Group on Information Technology R&D

Participating Agencies: AHRQ, DARPA, DOE, EPA, NASA, NIH, NIST, NOAA, NSA, NSF, ODUSD (S&T)

- High End Computing Coordinating Group (HEC)
- Large Scale Networking Coordinating Group (LSN)
- High Confidence Software and Systems Coordinating Group (HCSS)
- Human Computer Interaction & Information Management Coordinating Group (HCI & IM)
- Software Design and Productivity Coordinating Group (SDP)
- Social, Economic and Workforce Implications of IT and IT Workforce Development Coordinating Group (SEW)
- Federal Information Services and Applications Council (FISAC)

President's Information Technology Advisory Committee (PITAC)

- **Top IT experts from academia and industry**
- **Advises the Administration on how to accelerate the development and adoption of information technologies**
- ***Information Technology Research: Investing in Our Future (1999)***
  - Recommended increasing strategic investments from $1.46 billion in FY 2000 to $2.83 billion in FY 2004
  - Four priority areas for long-term R&D:
    - Software
    - High-end computing
    - Scalable information infrastructure
    - Socioeconomic impact

PITAC Reports

- **In 2000, three panel reports were released:**
  - *Resolving the Digital Divide: Information, Access and Opportunity*
  - *Transforming Access to Government through Information Technology*
  - *Developing Open Source Software to Advance High End Computing*
- **In 2001, three panel reports were released:**
  - *Transforming Health Care Through Information Technology*
  - *Using Information Technology To Transform the Way We Learn*
  - *Digital Libraries: Universal Access to Human Knowledge*

1997 - 2001 Membership Included:

Industry

- Eric A. Benhamou, Ph.D. / **3Com Corporation**
- Vinton Cerf, Ph.D. / **WorldCom**
- Steven D. Dorfman (retired) / **Hughes Electronics Corporation**
- David W. Dorman / **AT&T**
- Robert Ewald / **Learn 2 Corporation**
- James N. Gray, Ph.D. / **Microsoft Research**
- W. Daniel Hillis, Ph.D. / **Applied Minds, Inc.**
- William Joy / **Sun Microsystems**
- Robert E. Kahn, Ph.D. / **Corporation for National Research Initiatives (CNRI)**
- David C. Nagel, Ph.D. / **Palm, Inc.**
- Leslie Vadasz / **Intel Corporation**
- Andrew J. Viterbi, Ph.D. / **QUALC OMM Incorporated**
- Steven J. Wallach / **Chiaro Networks**
- Irving Wladawsky-Berger, Ph.D. / **IBM Corporation**

Academia

- Ching-chih Chen, Ph.D. / **Simmons College**
- David M. Cooper, Ph.D. / **Lawrence Livermore National Laboratory**
- Dave J. Farber / **University of Pennsylvania**
- Sherrilynne S. Fuller, Ph.D. / **University of Washington School of Medicine**
- Hector Garcia-Molina, Ph.D. / **Stanford University**
- Susan L. Graham, Ph.D. / **University of California - Berkeley**
- Ken Kennedy, Ph.D. / **Rice University**
- John P. Miller, Ph.D. / **Montana State University**
- Raj Reddy, Ph.D. / **Carnegie Mellon University**
- Edward H. Shortliffe, M.D., Ph.D. / **Columbia University**
- Larry Smarr, Ph.D. / **University of California - San Diego**
- Joe F. Thompson, Ph.D. / **Mississippi State University**

IT R&D Coordination Structure: OSTP & NSTC

OSTP:

- Created in 1976 to provide the President with timely policy advice and to coordinate the Federal science and technology investment
- Advises the President and others within the Executive Office of the President on the impacts of science and technology on domestic and international affairs
- Works closely with the NCO Director and Interagency Working Group (IWG) on IT R&D to coordinate the interagency Networking Information Technology R&D Program
- Oversees the National Science and Technology Council (NSTC)

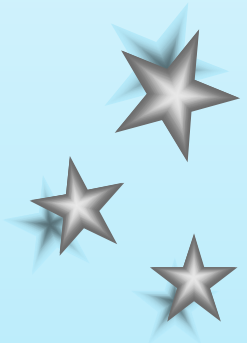
NSTC:

- Established by the President on November 23, 1993
- Cabinet-level council that is the principal means for coordinating science and technology across the Federal government

More information can be found at www.ostp.gov

Interagency Working Group (IWG) on IT R&D

- Serves as the internal deliberative organization of the NSTC for IT R&D policy, program, and budget guidance
- Oversees activities of six Program Component Area (PCA) Coordinating Groups and the Federal Information Services and Applications Council (FISAC)
- Provides technical assistance to and coordinates agency response to recommendations of the President's Information Technology Advisory Committee
- Membership consists of representatives from twelve agencies/departments, OSTP, OMB, and the NCO



National Coordination Office (NCO) for Information Technology Research and Development (IT R&D)

Mission: *To formulate and promote the Federal Information Technology Research and Development Program to meet national goals.*

- NCO Director reports to the Director of the White House Office of Science Technology Policy (OSTP)
- Coordinates planning, budget, and assessment activities for the Federal multiagency IT R&D programs
- Supports the six technical Coordinating Groups (CGs) that report to the IWG for IT R&D
  - Research planning workshops, conferences, and meetings
  - Presentations, white papers, and research reports
- Provides technical and administrative support to the IWG and PITAC
- Informs the public of Federal achievements and challenges in IT R&D
  - Maintains a Web site
  - Publishes annual budget documents in cooperation with the IT R&D agencies
  - Publishes PITAC reports

IT R&D Program Component Areas (PCAs) (1)

- **Six PCAs**
  - High End Computing (HEC)
    - Infrastructure and Applications (HEC I&A)
    - Research and Development (HEC R&D)
  - Large Scale Networking (LSN)
  - Human Computer Interaction and Information Management (HCI & IM)
  - High Confidence Software and Systems (HCSS)
  - Software Design and Productivity (SDP)
  - Social, Economic and Workforce Implications of IT and IT Workforce Development (SEW)

- **PCA Characteristics**
  - PCAs span areas with multiple agencies' involved
  - Each PCA includes hardware, software, algorithms, and applications
  - Each PCA focuses on specific R&D goals, ensures adequate investments, and maintains necessary budget visibility
  - Technology R&D may span PCAs
  - Applications span PCAs

IT R&D PCAs (2)

High End Computing (HEC)	• Advanced computing architectures including cluster and grids • Mass storage • Systems and applications software to exploit novel architectures • State-of-the-art computing systems available to researchers
Large Scale Networking (LSN)	• Network access, reliability, security, scalability, and management technologies • Active and intelligent networking and networking in extreme environments • Applications such as networks of sensors, grids, and collaboratories that require high performance networking and middleware • Testbeds
High Confidence Software and Systems (HCSS)	• Software and system availability, reliability, and safety • Information assurance, survivability, privacy, and security • Assured development and certification processes
Human Computer Interaction and Information Management (HCI & IM)	• Large scale data set processes, analysis, and visualization tools • Language-based data sets and analytical tools • Collaboratories • Multi-modal human-system interactions • Augmenting human performance
Software Design and Productivity (SDP)	• Software engineering of complex systems • End-user programming including domain-specific languages and intelligent templates, and programming by example • Component-based software development • Software for embedded systems
Social, Economic and Workforce Implications of IT and IT Workforce Development (SEW)	• Interdisciplinary research on the interactions and effects of IT in society • Curriculum development, fellowships, and scholarships • R&D in information-based learning tools, lifelong learning, and distance learning

The Internet:
A Federal IT R&D Success Story

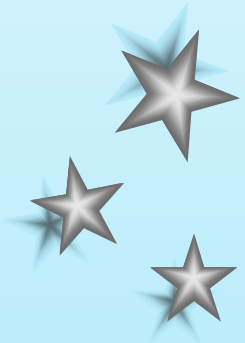
- The Internet was begun with DARPA funding for research to implement researcher-to-researcher exchanges of data (FTP) and text (HTML)

- The Internet has expanded dramatically, particularly in response to the next "killer application"
  - IP
  - Email
  - World Wide Web
  - What's next? We can't predict.

The Current Internet

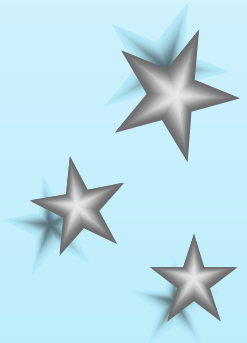
A key issue is end-to-end performance for end users

- Bandwidth is increasing dramatically by taking advantage of optical networking
  - Technologies include wave division multiplexing (WDM) and dense WDM
- Efficiency of bandwidth use is decreasing
  - The number of hops between users is increasing
  - Application/network interfaces aren't well tuned
- Local area networks and local access are often bottlenecks
  - Technology is needed for:
    - Remote access
    - Tether-free access
    - Increased bandwidth for end-user access

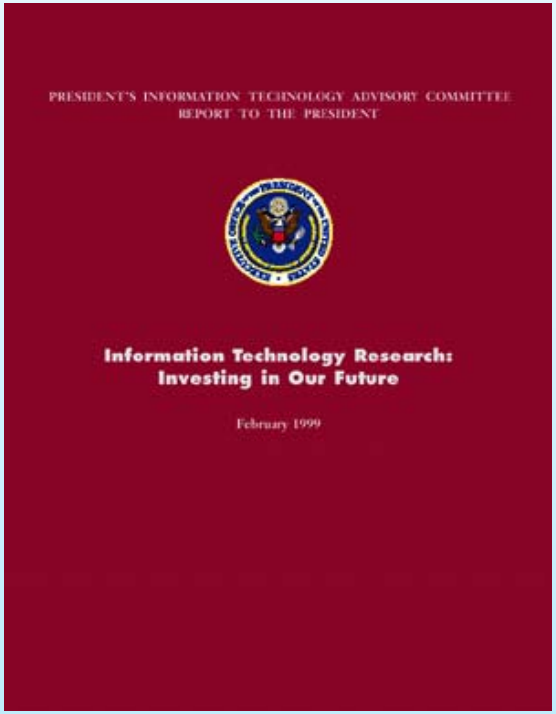


The Future of Networking

- All optical networking
  - End-to-end optical is needed for end-user performance
  - Optical switches are under development using micro-electro-mechanical systems (MEMS)
- Wireless systems and services
- Practical voice command
- Networks are needed to support:
  - Grids that connect distributed computing systems, storage, and databases
  - Collaboratories with security, quality of service (QoS), and high assurance
  - Sensor nets — billions of networked embedded sensors
  - Unforeseen future applications



In it's February 24, 1999 Report to Congress, "Information Technology Research: Investing in Our Future" the PITAC provided IT R&D priority recommendations to the Interagency Working Group . . . .



PITAC Recommendations Impacted PCA Framework (1)

- **The investment in High End Computing and Computation is now reported as two new PCAs to better characterize the breadth of the investment.**
  - High End Computing Infrastructure and Applications (HEC I&A)
  - High End Computing Research and Development (HEC R&D)
- **Human Computer Interaction and Information Management (HCI & IM) succeeds the Human Centered Systems (HuCS) PCA, reflecting the increasing challenges of making large amounts of information easily available and useful to the widest variety of users.**
- **Large Scale Networking (LSN) activities include the Next Generation Internet (NGI) Initiative and scalable information infrastructure R&D.**
- **Software Design and Productivity (SDP) was a new PCA in FY 2000, established in response to the PITAC's finding that not only is the demand for software exceeding our ability to develop it, but the software produced today is difficult and costly to design, test, maintain, and upgrade.**

PITAC Recommendations Impacted PCA Framework (2)

- **High Confidence Software and Systems (HCSS) was formerly the High Confidence Systems (HCS) PCA. Its new name and scope reflect the increasing need for adaptability, reliability, safety, and security in both the software and the systems that U.S. citizens count on each and every day.**

- **Social, Economic, and Workforce Implications of IT and IT Workforce Development (SEW) is the successor to the Education, Training, and Human Resources (ETHR) PCA. SEW's expanded R&D portfolio now includes assessment of the social and economic consequences of IT's transforming influence on the workplace as well as expanded research in education and worker training issues resulting from the rapid U.S. move to an information-based economy.**

In each of these major research areas, PITAC offered specific recommendations. . .

High-End Computing

PITAC Recommendations -

- Fund R&D on software to improve the performance of high-end computing.
- Drive high-end computing research by trying to attain sustained petaops/petaflops on real applications by 2010 through a balance of software and hardware strategies.
- Fund the acquisition of the most powerful high-end computing systems to support scientific and engineering research.
- Expand the NSTC CIC High-End Computing Working Group's coordination process to include all major elements of the government's investment in high-end computing.
- Increase funding for high-end computing R&D and acquisitions: add $270M in FY2000 … add $430M in FY2004.

High-End Computing (1)

Accomplishments -

- Overall funding in high-end computing has increased:
  - Budgets have increased
  - New NSF-sponsored Information Technology Research program
  - Continuing NSF focus on Terascale effort
  - Instrumental in attracting and retaining talented researchers

- Novel and innovative architectures for high-end computing are being aggressively explored on several fronts:
  - Cluster and grid computing
  - High performance computing and storage devices
  - Very Large Scale Integration (VLSI) of photonics for intra-chip and inter-chip communications
  - Development of three-dimensional multi-chip modules
  - Development of optical tape technologies that can store one terabyte of information on a single, standard, hand-held tape cartridge

High-End Computing (2)

Accomplishments -

- R&D in software for high-end computing has increased significantly within the Federal government
  - System-level software (which performs resource allocation, management and control)
  - Middleware (which connects low-level system functions with higher-level software and applications)
  - Software support (such as reusable software libraries) common to many applications
  - Applications algorithms
- New system has been installed at the DOE's ASCI facility at Lawrence Livermore National Laboratory. Dubbed "Option White," this is a scalable prototype for a 12.3 teraops system that is currently the fastest computing platform in the world.
- New system installed at Pittsburgh Supercomputing Center is fully operational, and has achieved 75% of peak 6.0 teraflops. Rated number 2 in fastest 500 computers worldwide.

Scalable Information Infrastructure (SII)

PITAC Recommendations -

- Fund research in the behavior of the global-scale network and its associated information infrastructure.
- Support research on the physics of the network, including optical technologies, wireless technologies including satellites, wired technologies including cable and related bandwidth issues.
- Support research to anticipate and plan for scaling the Internet.
- Support research on middleware that enables large-scale systems.
- Support research on large-scale applications and the scalable services they require.
- Fund a balanced set of testbeds and research infrastructure that serve the needs of networking research as well as research in enabling information technologies and advanced applications.
- Increase funding for SII R&D: add $60M in FY2000 … add $300M in FY2004.

Scalable Information Infrastructure (1)

Accomplishments -

- LSN agencies fund multiple research projects on:
  - Active intelligent networking
  - Security and information assurance
  - Dynamic network management
  - Performance measurement and modeling
  - Optical networking technologies and management
  - Scalable services for global networking
  - Grid networking and application development
  - Networking for distributed sensors

Scalable Information Infrastructure (2)

Accomplishments -

- Wireless technologies
- Quality of Service
- Hybrid technologies (satellite/terrestrial)
- Development of the 100 X testbed and the 1000 X testbed (Supernet) to support applications development and networking research

PITAC Review of NGI and its Impact

- PITAC reviewed the NGI program in 1999 and 2000
- Findings
  - The NGI Program has made excellent progress
  - "More applications should be funded that demonstrate the utility of the NGI's Gigabit bandwidth to end-users, its increased security, and its expanded quality of service"
  - Federal agencies should provide more capability to measure network performance
  - Congress should consider additional funding for a program where the NGI research institutions act as aggregators and mentors for nearby smaller or disadvantaged institutions.
- Impact
  - PITAC findings contributed to continued NGI funding
  - Federal agencies significantly increased the funding of NGI applications
  - NGI agencies funded performance measurement of NGI networks
  - NGI agencies funded Educause to assist smaller institutions in taking advantage of high performance networking

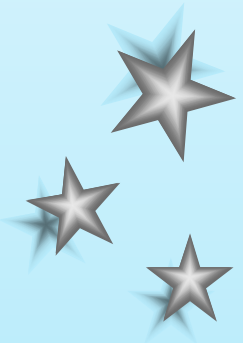
After NGI: Large Scale Networking R&D

- March 12-14, 2001 Workshop on New Visions for Large-Scale Networks: Research and Applications
  - Workshop report released August 2001
- August 22, 2001: LSN agency planning meeting
- September 24-25, 2001: PITAC Scalable Information Infrastructure review of LSN R&D

LSN New Visions Workshop

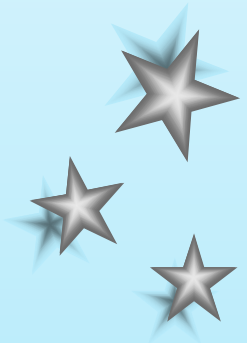
- Objectives
  - Develop a vision for the future of networking (10 to 20 years out)
  - Develop guidance from the private-sector networking research community on networking research
  - Identify needed Federal networking research to help realize the vision

- Participants included more than 160 people from:
  - Universities
  - Industry
  - Research laboratories
  - Federal agency networking research organizations



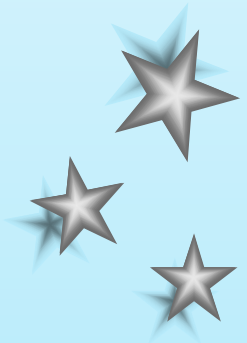
LSN Workshop: Research Needs

- Adaptive, dynamic, and smart networking
- Measurement, modeling, simulation, and scalability
- Trust: security, privacy, and reliability
- Networking applications
- Networking middleware
- Testbeds
- Collaboration environments
- Revolutionary research
- Revisit networking fundamentals



Areas for Interagency LSN Cooperation

- End-to-end systems
- Grids and collaboratories
- Mobile networks and hybrid systems
- Network measurements, modeling, simulation, and monitoring
- Networking security
- Testbeds
- Transport protocols and control theories



Software

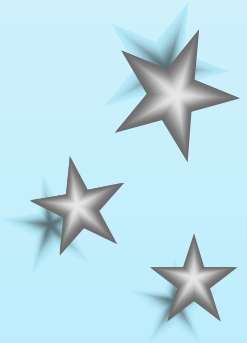
PITAC Recommendations -

- Make fundamental software research an absolute priority.
- Make software research a substantive component of every major information technology research initiative.
- Fund more fundamental research in software development methods and component technologies.
- Support fundamental research in human-computer interfaces and interaction.
- Fund more fundamental research in information management technologies to (1) capture, organize, process, analyze, and explain information, and (2) make information available for its myriad uses.
- Increase funding for software R&D: add $112M in FY2000 … add $540M in FY2004.

Software

Accomplishments

- Clarified and expanded software research efforts
  - High Confidence Software and Systems (HCSS) PCA
  - Software Design and Productivity (SDP) PCA
  - Human Computer Interaction and Information Management (HCI&IM) PCA
- Increased IT R&D funding
  - Primarily at NSF, but mission agencies also had increases
- All PITAC recommended areas being funded
- Expanded interagency planning and collaboration



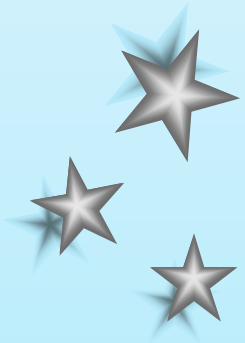
High Confidence Software and Systems (HCSS) (1)

- Report on "High Confidence Software and Systems Research Needs" released January, 2001

- Current agency activities
  - NSF has two new programs funded in FY 2002
    - Trusted Computing
    - Embedded and Hybrid Systems
  - NASA
    - High Dependability Computing Consortium
    - Software Model Checking
    - Modular Verification of Integrated Avionics

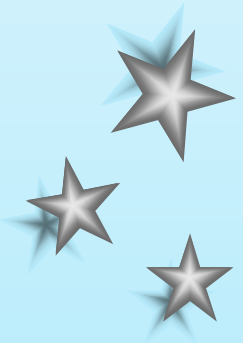
High Confidence Software and Systems (HCSS) (2)

- NSA
  - CRYPTOL: Domain-specific Language for Cryptography
    - Compiler for cryptographic processing
    - Allows formal specification of algorithms and formal verification of implementation
  - Software Modeling Reliability Study:
    Automatic Testing Tool for High-Assurance Software
  - System Information Assurance:
    The “Programatica” Development Environment
    - Simultaneous creation of formal system properties and executable programs
    - Allows high-assurance verification of correctness assertions
  - High-Confidence Nuclear Command & Control Software



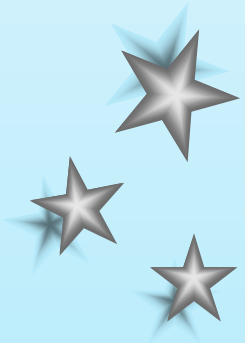
SDP Planning Workshop on New Visions for Software Design and Productivity

- Held April 18-19, 2001 in Arlington, VA
- Objectives
  - Bring together leading-edge researchers and practitioners
  - Encourage brainstorming and out-of-box thinking
  - Inform the research agenda
  - Raise the visibility of SDP
  - Involve Federal agencies and research community
- Participants from:
  - 14 universities and non-profits
  - 8 commercial enterprises
  - 11 Government agencies



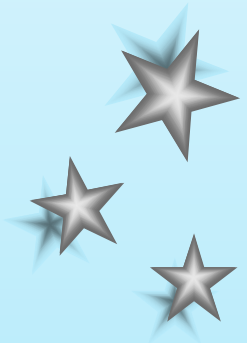
The Scope of Software Design and Productivity (SDP) has Changed Over the Years

- Expanding challenges for software design
  - From unattended to human-centric
  - From legacy to net-centric
  - From desktop to embedded and mobile-global
  - From stand-alone to complex systems of systems
  - Long-lived and pervasive
  - Multi-intent and multi-faceted
  - Accidental complexity: incompatible models, languages, platforms, methods, standards
- Expanding challenges for productivity
  - Larger and more diverse systems
  - Pervasive demand
  - Increased criticality
  - Global teams and interoperability
  - Workforce



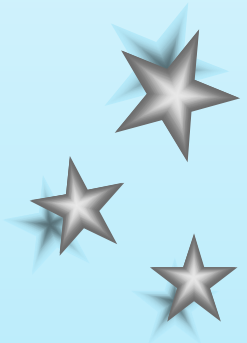
Second Workshop to Define SDP Research Needs

- Workshop on New Visions for Software Design and Productivity: Research and Applications held December 13-14, 2001 at Vanderbilt University in Nashville
- Workshop report in final review
- SDP Coordinating Group will use workshop results to plan and implement an enhanced R&D agenda



Human Computer Interaction and Information Management (HCI&IM) Agency Needs Assessment

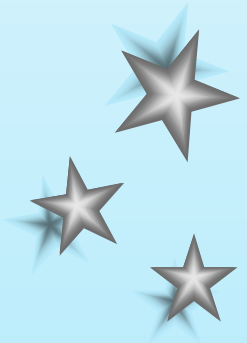
- One-day agency workshop held October 22, 2001, to review research programs and needs
- Workshop results being used to expand HCI&IM vision and scope
- Vision and scope will be used in articulating HCI&IM R&D needs



Social, Economic & Workforce (SEW) Issues

PITAC Recommendations -

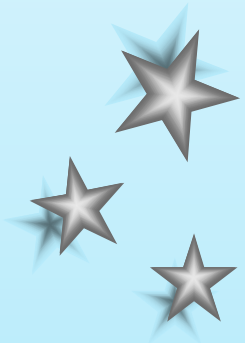
- Expand Federal research into policy issues arising from information technology.
- Fund information technology research on socioeconomic issues.
- Expand the participation of underrepresented minorities and women in computer and information technology careers.
- Create programs that remove the barriers to high bandwidth connectivity posed by geographic location, size, and ethnic history of research, educational institutions, and communities.
- Accelerate and expand education in information technology at all levels K-12, higher education, and lifelong learning.
- Strengthen the use of information technology in education.
- Increase funding for SEW R&D: add $30M in FY2000 … add $100M in FY2004.



Social, Economic & Workforce Issues (1)

Accomplishments -

- Begun in FY 2000, NSF's multidisciplinary Information Technology Research (ITR) program explicitly encouraged SEW-related proposals
- Strong SEW response to ITR solicitation
  - In FY 2001, 18% of 1,390 ITR proposals were SEW-related, and 38 SEW projects totaling $14 M were funded
  - In FY 2001, the ratio of SEW proposals to all ITR proposals was the same, and funding for new and continuing SEW projects rose to $26 M
- Current research in socioeconomic impacts of IT includes:
  - Effects of e-commerce and the digital economy
  - Community networking
  - Computer-supported collaborative work
  - IT and transformations in work life
  - Value systems in IT design, deployment, and consequences
  - Information privacy and intellectual property
  - The role of IT in facilitating scientific progress
  - Technologies and tools enabling people to use IT regardless of age or physical limitation



Social, Economic & Workforce Issues (2)

Accomplishments -

- Current IT education and workforce development activities:
  - NSF program in barriers to IT careers for women and minorities
    - www.nsf.gov/sbe/ses/
  - NSF research in methods to increase IT literacy and skills
  - DOE Computational Science Graduate Fellowship program – provides advanced hands-on training for graduates students at DOE labs
    - www.krellinst.org
  - NLM graduate and postdoctoral training programs in bioinformatics
    - www.nlm.nih.gov/pubs/factsheets/trainedu.html
  - NASA Learning Technologies Project – provides IT-based science curricula and learning modules for students
- Other SEW activities:
  - February 2002 workshop on "The Research Agenda in Open Source Software"
  - May 2002 conference on "Understanding the Digital Economy," in collaboration with the Department of Commerce

Additional PITAC Recommendation

- Create a Balanced IT Research Portfolio
  - NSF explicitly implemented PITAC's recommendations:
    - Larger individual grants – for longer terms
    - Increased the number of researchers
    - Support for thematic programs – special initiatives
    - Progress on encouragement and support for multidisciplinary research to further understanding of software science

Impact of PITAC

- PITAC has raised awareness of the critical need for increased Federal IT funding.
- PITAC has directly influenced the agencies' research programs to be more aligned with future industry and mission needs.
- PITAC has been a mechanism for educating industry about the resources available in the Federal IT R&D Program.

Types of Industry Involvement in Agency Research

- CRADAs
- Collaboration
- IPAs
- Consortia
- Start-ups
- Tech transfer
- Procurement
- Standards development
- Advisory Committees . . . .

Examples of Industry Involvement in Agency Research (1)

- Federal agencies contract with the commercial sector for research and development
  - Web 100: Intel, Sun, and others are developing an automatically tuned application/network interface.
  - All optical networking: Ciena and others are developing key optical networking components.

- Federal agencies purchase network services from commercial providers, giving the providers direct experience with high-performance networking. Providers contribute significant services and equipment (value is many times the Federal contribution)
  - vBNS+ (NSF) is provided by WorldCom
  - DREN is provided by AT&T
  - ESnet is provided by Qwest
  - NREN is provided by Qwest

Examples of Industry Involvement in Agency Research (2)

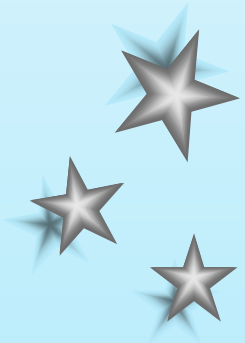
- Commercial sector participates directly in Federally funded testbeds, e.g. Quality of Service Backbone network (Qbone) participants include NASA, NSF, DoD, Internet2, Cisco, Spirent, Torrent/Ericsson, and Nortel. The commercial sector provides services and equipment for testing.

- The commercial sector participates in the Joint Engineering Team (JET) that architects the advanced R&D networks: Cisco, Qwest, and WorldCom.

- MAGIC (Middleware And Grid Infrastructure Coordination) Team has just been established to address technical and engineering issues associated with coordinating middleware and Grids. It will include representatives from Federal agencies, industry, academia, and other groups with an interest in middleware and Grid infrastructure.

Compelling Reasons for Continued Federal IT R&D Funding (& Multi-agency Coordination) (1)

- Federal agencies need advanced information technologies to meet their mission goals
  - Advanced IT is needed not only in its own right but also in both R&D and applications in all scientific and engineering endeavors
    - This includes biology, chemistry, mathematics, physics, and engineering ranging from designing aircraft design to developing advanced medical diagnostic and treatment devices
- IT R&D is needed to developed these technologies
- There is substantial overlap in agency needs
  - Coordination enables the Federal R&D agencies to leverage their investments, eliminate duplication, and identify and address research gaps
- Different agencies have different funding mechanisms
  - Advantages include flexibility and the ability to have several agencies fund projects, each with different goals



Compelling Reasons for Continued Federal IT R&D Funding (2)

- There is substantial overlap between Federal needs and private sector needs
  - Examples include high end computing, high speed networking, large database technologies
  - Federal needs can be larger than private sector needs (at least initially)
  - Some Federal needs will always be different from private sector needs (national defense and national security are examples)

- Results from Federally-funded IT R&D have benefited the private sector
  - Past Government-funded IT R&D has yielded huge economic returns on investment, and continues its pivotal role in promoting innovation
  - Funding research helps the intellectual base grow, thereby ensuring continued innovation
  - Federal IT R&D investments that address agency mission needs often anticipate private sector needs
    - An example is technologies to help guarantee availability, reliability, security, and privacy of information systems, which are current IT R&D areas

Compelling Reasons for Continued Federal IT R&D Funding (3)

- Federal IT R&D investments and private sector IT R&D investments are complementary
  - The Government invests in general-purpose, broadly useful, and interoperable technologies, tools, and applications
  - The Government can invest in technologies that may take decades to mature
  - The inability to appropriate a ROI in generic technologies by an individual company prevents such an investment
  - A company invests in technologies that give it competitive advantage and looks to the next quarter for its return on investment

- Much of what the Federal government funds is performed or provided by the private sector
  - University based research
  - University research infrastructure (including computing systems and advanced networks)
  - R&D performed by industry for agencies including DoD, DOE, and NASA

Compelling Reasons for Continued Federal IT R&D Funding (4)

- Transfer to the private sector of both information technologies and people who can create and use these technologies is a natural by-product of Federally-funded IT R&D

- Today the U.S. relies heavily on its IT leadership to maintain national security, national defense, and economic competitiveness, and continued Federally-funded IT R&D helps assure that leadership in the future

Agency IT R&D Budgets by PCA

FY 2002 Budget Request (dollars in millions)

Agency	HEC I&A	HEC R&D	LSN	HCI& IM	HCSS	SDP	SEW	Totals
NSF	249.7	65.1	98.0	104.8	46.1	39.7	39.1	642.5
DARPA	55.5	42.7	49.2	38.2	32.9	44.6		263.1
NIH	55.1	13.7	81.1	74.6	10.1	6.0	11.4	252.0
NASA	36.1	26.0	14.4	27.8	47.1	22.4	7.0	180.8
DOE Office of Science	98.3	31.5	25.9	16.4			4.0	176.1
NSA		33.6	1.9		46.6			82.1
NIST	3.5		3.2	6.2	7.5	2.0		22.4
NOAA	13.3	1.8	2.7	0.5	1.5			19.8
AHRQ			6.7	9.2				15.9
ODUSD (S&T)		2.0	4.2	2.0	1.0	1.0		10.2
EPA	1.8							1.8
Subtotal	***513.3***	***216.4***	***287.3***	***279.7***	***192.8***	***115.7***	***61.5***	***1,666.7***
DOE /NNSA	133.8	37.0	35.5			41.1	56.5	303.9
Totals	**647.1**	**253.4**	**322.8**	**279.7**	**192.8**	**156.8**	**118.0**	**1,970.6**

For Further Information on Federally Funded IT R&D

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